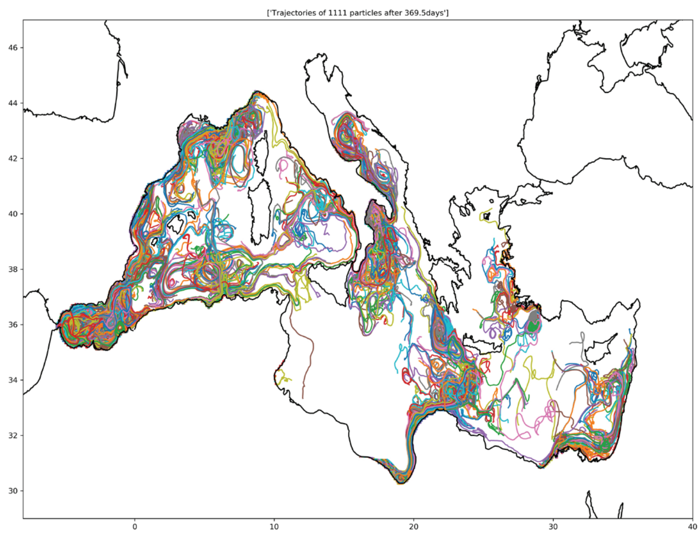
MULTI-RESOLUTION GLOBAL MODELLING OF SURFACE CURRENTS

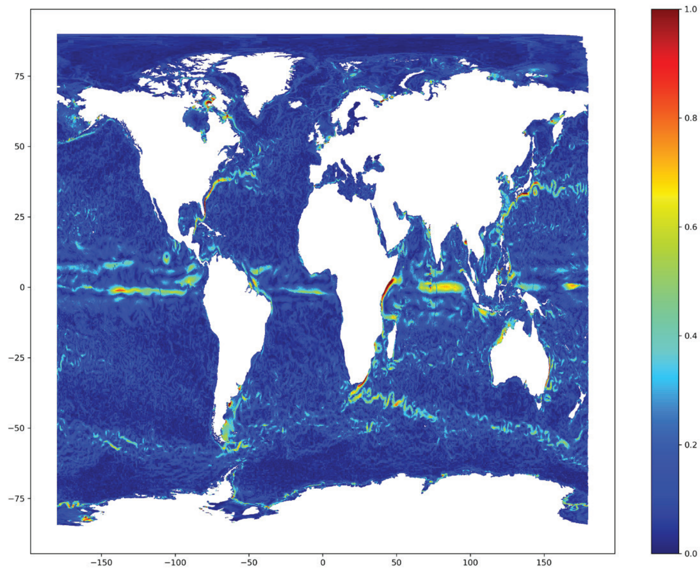
Deltares has developed the Global Tide and Surge Model (GTSM) in recent years. The model shows total water levels, including tides and meteorologically driven surges, on a global scale.

The GTSM is the first model of its kind, and applications vary from hydrographic services to global flood risk assessments and climate change studies. Given the growing popularity and global scale of the model, external parties have started to show interest in it as a tool for predicting surface currents, a factor of crucial importance for navigation. An ongoing project for Akzo Nobel, the sponsor of the Dutch team in the Volvo Ocean Race, provides the sailing team with current forecasts. However, the currents driven by ocean density were not included in the 2D setup. The development of a three-dimensional version of the GTSM has opened up the market for navigation and other large-scale transport-related issues such as plastic transport.

The Delft3D-FM software can represent 3D flows driven by wind forcing and density differences. The main oceanic currents, however, are the result of the large-scale thermohaline circulation, which takes thousands of years to spin up to its current mean state. Furthermore, long-lived ocean eddies tend to form randomly. These eddies are chaotic and characterised by high velocities. Information about them is therefore of major importance for navigation and transport. Assimilation is required in order to represent and forecast these two phenomena accurately in the 3D hydrodynamic model. The assimilation will spin up, sustain and guide the currents in the right direction. A nudging technique has therefore been implemented in the Delft3D-FM software in order to include information about temperature and salinity fields from other sources such as the Ocean Circulation model and satellites. This technique allows us to combine the best capabilities of two types of models: the Ocean Circulation Models in deep waters, and the 3D hydrodynamic model on shelves and coasts.



Final location of particles calculated after one year



Surface velocities from the 3D GTSM using the nudging technique

Using the nudging technique, the model successfully reproduced large-scale surface velocities like the Gulf Stream and mesoscale eddies detached from the Agulhas Current in South Africa. It is important to represent eddies in plastic simulations properly so that we capture where the plastic is transported and where it may accumulate. The plots show distinct accumulation zones of plastics around eddies.

Running models of this kind poses a challenge in terms of computational resources and capabilities. The model contained more than 2 million nodes in the horizontal direction and 43 layers in the vertical direction. This model size has never been exceeded in Deltares in the past. Future developments include the validation of currents, global-scale study of plastic transport and the improvement of memory issues involved when running large models.

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